CHARACTERIZATION OF THE ELECTROMECHANICAL PROPERTIES OF IPMC

Yoseph Bar-Cohen[1], Kaushik Bhattacharya[2], Xiaoqi Bao[1], Shyh-Shiuh Lih[1], and Xiao Yu[2]

ABSTRACT

Ionic Polymer-Metal Composite (IPMC) as electroactive polymers (EAP) was the subject of research and development since 1992. Its low required activation voltage and the large bending led to the considerations of various potential applications. However, before the benefits of IPMC can be effectively exploited for practical use, the electromechanical behavior must be properly quantified. An experimental setup was developed for data acquisition from IPMC strips subjected to various tip mass levels and in parallel an analytical model was developed to predict the material response. Using the analytical model and an inversion algorithm the modulus, and relaxation time were determined. The programmable setup was used to acquire the displacement and curvature of IPMC as a function of the electrical signal characteristics. Sample strips were immersed in water to minimize the effect of moisture content and were tested with and without tip mass. In order to avoid hydrolysis the samples were subjected to 1-V square wave with either positive or negative polarity. A multi-scale model was developed that showed satisfactory results for tetra-n-butylammonium$^+$ cations/Flamion IPMC, which responds slowly and monotonically without relaxation. This model starts at the mesoscale level with three fully coupled partial differential equations in cation concentration, electric potential and elasticity. Solution in the strip geometry leads to a macroscopic ordinary differential equation whose solution fits the observed behavior very well. Deviation from the model was observed when the material shows relaxation, as in the case of Li^+ cations/Nafion. This type of IPMC has history dependence and responds with a quick bending that in fractions of a second starts relaxing and address this deviation would require further studies.

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[1] JPL (MS 82-105), 4800 Oak Grove Drive, Pasadena, CA 91109-8099, yosi@jpl.nasa.gov, web: http://ndeaa.jpl.nasa.gov
[2] Division of Engineering and Applied Science, Mail Stop 104-44, Caltech, bhatta@caltech.edu